2D Visual codes: Why are they not everywhere?

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Abstract

One key characteristic of ubiquitous computing is the disappearing boundary between physical and virtual elements, a mindset shift from interaction with the computer to the interaction with the environment. 2D visual codes are an important enabling technology for this increasing integration between physical spaces and virtual. However, despite the availability of a broad range of technologies for 2D visual codes, their common usage is still far from being a reality. In this work, we explore some of the factors that may influence the adoption of such interaction techniques. The study was based on the development of a prototype in which a set of applications was made available through interaction with visual codes. The prototype was deployed for three months in a public setting where users could try this technology for themselves. The results from the study suggest that visual codes are seen as a simple interaction model, but still some brief initial introduction may be needed. The study has also highlighted some functional limitations and strong technical constraints that proved to be very demanding when considered in the context of a real scenario and using people's own devices. Although the curiosity factor plays very favourable to the visual codes, its generalized adoption will be difficult or, at least, will not happen as spontaneously as a simple demo may initially suggest.

Keywords

Visual codes, TRIPcodes, physical/virtual merging, mobile applications, ubiquitous computing.

1. INTRODUCTION

One of the central ideas of ubiquitous computing is that interaction with information systems can be associated with physical space events. There is a wide range of techniques, including several types of sensors, electronic tags, image recognition, touch sensitive areas, and others, that may enable this integration. 2D visual codes belong to the image recognition techniques and represent information through the use of geometric figures and colour patterns. Usually these symbols are also known as tags or codes. A great advantage of this technology is the possibility to be used by current mobile devices that have an integrated camera, not requiring any extra hardware component. The codes can be photographed and interpreted based on algorithms for image recognition, designed to work with very limited computing capacity and low-image resolution devices. For decoding is necessary to install a small application, usually known as tag reader. Having the application installed, interaction with the system boils down to start the application, point to the tag, and "trigger" the functionality. Hence the *point&click* designation for the interaction model behind this technology.

There are several technologies for 2D visual codes, including some commercially available [Semacodes05, Spotcodes05]. Its use is already a fact in some specific scenarios, such as marketing activities (get a bonus to whom trigger the code), to obtain detailed information on a given product (in libraries, supermarkets), and advertising (avoiding manual data enter for URLs).

However, the current use in everyday context is yet far from common. There several limitations, particularly in the development of applications that benefits from this new model and overcome certain remaining constraints, which are mainly related with the use of an incipient technology running on a device type constantly changing and without relevant standards.

The main goal of this work was to study acceptance factors for visual codes and also to discover which issues could jeopardise their apparent potential.

To evaluate these factors, this work was based on a prototype developed and deployed in a real-world setting during three months. Under this prototype were deployed several types of applications (services), all of them supported by a particular type of 2D Visual codes, the TRIPcodes technology [Tripcodes05].

For this study, a specific user's community was selected: young people, prone to the use of new technologies, thereby explicitly avoiding other constraints of general population and focusing on those most directly related factors to the visual codes adoption. Users would have to feel self-motivated to participate and use their own devices, implying to receive and install a client application – TRIPcode reader.

During the evaluation period, application usage logs were recorded and observation sessions taken. After that, interviews and surveys were carried out. The analysis of the results shows that there was a low uptake, primarily due to technical constraints. From the users perspective, applications will have to be convincing, low-cost or free of charge, allowing an easy installation and configuration and, finally, *bugs-free* applications or, at least, having technical difficulties well controlled (installation, usage, service availability). From the mobile devices manufacturers' perspective, a strategy to define and apply standards must be followed. Finally, in the software developers' corner, testing as many brands/models as possible is recommended, a strong bet when launching a product/service must be made, and provide some level of basic information but always in an objective and simplified way.

Section 2 sets out some work related and which served also as inspiration for the project. Section 3 describes the study itself, summarizing the technology, the platform, and the prototype. In section 4, we analyse the results and finally the main conclusions are outlined in section 5.

2. RELATED WORK

Although an emerging technology, there are already several studies on technical issues such as the type of code selected, the percentages of successful readings, mechanisms for handling errors, colouring the tags, image processing speed, paper influence, printing quality, from lenses and angles up to the space lighting, among others [Rekimoto00, Rohs04a, Moravec02, Nuutinen05, Ballagas06, Rohs04b, Scott05, Ababsa04, Ravi06]. Nuutinen [Nuutinen05] have also examined issues related to usability and ergonomics.

Toye et al. [Toye07] addressed the adequacy of mobile phone as a vehicle for interaction with a ubiquitous system through visual codes. The study was conducted in a laboratory, so issues such as people acceptance, problems with diversity of mobile devices, need to install an application reader, among other dilemmas, were not a concern, as opposed to the work described on this paper. Wagner [Wagner05] investigated about this interaction model versus suitability in several age-groups. Also refers to hardware and software related requirements.

There are other studies whose aim is to try to understand how phones with camera are being used by the population in general, trying to establish usage patterns in order to propose an appropriate taxonomy [Kindberg04, Kindberg05].

What characterises our study is the goal of assessing the adoption of the technology in a broader context, avoiding an approach driven by mainly be technical or usability concerns.

3. DESCRIPTION OF THE STUDY

The main goal of this study was to discover constraints and enablers for the visual codes adoption in the context of interaction with a system. Regarding the approach, it was chosen to deploy a prototype in a real environment with a set of functionalities based on the interaction with TRIPcodes.

3.1 Assessment Parameters

The assessment was made based on the following parameters:

a. **Simplicity of the interaction model**: To assess the simplicity degree this interaction model can provide. Evaluate if users can start using the application without having previously been instructed on how to do so.

b. **Format/use relation**: To discover the impact of several presentation forms (in brochures, printed and wall-mounted, and in public displays). Test different sizing. Assess relationship between the ease, comfort and efficiency of use.

c. **Feedback perception**: To evaluate the effectiveness of different reply alternatives to the user stimuli (no confirmation at all, public display viewing, or just in its own mobile).

d. **Functional and technical constraints**: Check whether there are "hidden" constraints in the use of visual codes such as privacy invasion fears, security, personal embarrassment, and how possible technical difficulties are handled.

3.2 Visual Codes Technology

There are several types and formats for 2D visual codes [ActivePrint05, Colorcode05, PaperClick05, PrintAccess05, Semacodes05, Spotcodes05, Tripcodes05, VisualCodes05, Rekimoto00]. For the purposes of this study it was used the TRIPcode technology [Tripcodes05], monochromatic symbols of variable size, allowing tag values between 1 and 19683 whose visual effect is of circles around a central point as represented by the image below.

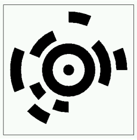

Figure 1 – TRIPcode example [tripcodes05]

The reasons for this choice were due to the following facts:

- Both the basis for supporting the server-side (TripListener) and the client-side (TripReader) were in open-source.
- The scripts to generate new TRIPcodes tags were available and unrestricted.
- Source-code developed in Java allowed platform independence.
- The base application chosen already supported bluetooth as communication protocol between server and client. This feature accomplished the project premises concerning the exemption of costs to the users.
- Very simple architecture and without major hardware requirements.

3.3 Functionality

When considering which functionality to develop, we have tried to combine different types of application, namely applications whit personal value, group value and community value. In the end, we developed 15 different services which included:

- Features of interest to the single user, regardless of whether others use them or not, type I functionalities according to Mansley' taxonomy [Mansley04]. Examples: provide information about the project, information about teachers' availability, manage personal data.
- Features of interest to subgroups of the population, type II functionalities according to Mansley. Example: functionalities related with buddies and messages.
- Features for the users' community, Type III according to Mansley. Example: listing the top 10 most active users, sending messages into a public display, polls.

3.4 Platform

The system consisted of 4 major applications: the site, the client application (TripReader), the client application diffuser (TripPusher) and the receiver of client's communications (TripListener).

The site served both as public project information source and as a private backoffice/administration area. The TripReader, TRIPcodes reader, was the application users had to install on their devices so that they could interact with the system. The TripPusher sent the application automatically to the bluetooth devices it randomly discovered. The TripListener was responsible for invoking the available services when they were activated by users.

On the server-side were necessary: a database, a web server, and an environment to run specific scripts both supporting public displays application and one, or more, *application servers*. An application server could be a TripPusher or a TripListener, ideally in a different physical computer. To this set of components was generally defined by TripServer.

On the client-side, it could be used the mobile device to interact with the application (desirable scenario) or via a browser (generally using a PC or equivalent) to some generic tasks such as project general information, register, manage features, and customizations.

Regarding to the deployment hardware requirements, would be a minimum to install a single server machine that contained a bluetooth dongle and handle all TripServer components. However, to provide proper support to functionalities such as "where is a given user", should be available several *application servers*. Thus, were scattered in different places 4 computers in order to provide basic coverage, and therefore some usefulness of such services.

3.5 Deployment

The prototype was made available in the Information Systems Department at the University of Minho. The coverage areas were the main areas of students' frequency, including laboratories, educational activities and their access areas.

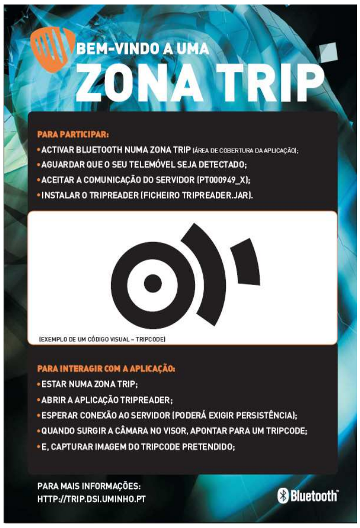

Figure 2 – TRIP project poster - Trip Zone

The project disclosure was carried out by advertising posters (see figure 2), an initial email with project introduction sent to all population students, printed TRIP-codes and public displays in some strategic locations. Although there was no formal introduction to the project and to the participation modus, the site provided project reference and was promoted by the advertising vehicles. The site contained all the explanations required to participate. The zones covered by TripServers were marked by posters like the one shown in Figure 2.

4. ANALISYS OF THE RESULTS

The defined population was set as the students of Information Systems Department. But to participate was a necessary requirement to have a mobile device that, cumulatively, supported the following features: bluetooth, camera and environment for Java applications. Certainly this requirement substantially reduced the target audience.

For data collection, some occasional sessions of indirect observation were made during the evaluation period, interviews and surveys were also used after the evaluation period has finished. The following table shows the applied inquiry tools:

Tool	Sample	Participants	Non Participants
Interview	7	3	4
Survey	15	4	11

Table 1 - Sample for inquiring tools

After the evaluation period, although more than 45 individuals have registered in the site and tried to participate, only 8 users managed to successfully complete the registration process by themselves and interact with the available services through their own mobile devices. These users had a total of 162 interactions with the system, generating an average of 1.7 interactions per day.

The results of the polls, launched in the application, were also considered for the conclusions of the study.

The following subsections will summarise the more significant findings in the study, according to the previously presented assessment parameters.

4.1 Simplicity of the interaction model

According to the surveys and interviews, the majority had no previous knowledge whatsoever of visual codes. Nevertheless, interaction issues mainly occurred in the first attempts of usage. But, based on the answers to surveys and statements in the interviews, only around 40% of the subjects would be able to use the application without prior explanation.

Despite the underlying model being basic and simple, it became clear that it is necessary, at an early stage, to provide some basic assistance. There were several cases where, in the first use, people showed uncertainty on how to interact. The two situations most recurrent were: either, knowing they would have to "shoot" the codes, opened the regular camera application instead of TripReader or, by opening the correct application, were awaiting for a suggestion of what to do then. After a brief explanation, or after a simple demonstration, the doubts were cleared and no further difficulty appears to stop them.

As stated by Toye et al. [Toye07], it was confirmed the need for something that identifies the tag being pointed by some signal on the mobile display, for example an overlaid text, giving a perception that decoding will occur correctly or even what functionality will be triggered.

Stated in surveys, 75% rated very quickly to understand, during the first attempt, how to use it. Similar perception was also obtained from the observation sessions.

Regarding the degree of satisfaction provided by this type of interaction, users rated it as satisfactory.

4.2 Format/use relation

Regarding the goal to assess the relationship between size and shape, no one expressed difficulty or preference. When queried about the importance of the TRIPcode size, 50% percent in the interviews and more than 71% in the surveys stated no impact was noticed. Nevertheless, through observation method, it was found that there was a tendency to use the TRIPcodes with a larger dimension, particularly in those that were posted on the wall. There was also a trend towards greater usage of the ones that were printed and very low usage on the ones shown on public displays. Although, according to the surveys statements, the majority referred that it was so easy to use the TRIPcodes printed on paper as the ones displayed on a screen.

There was no case of using codes carried by the users. They always used the codes that were available in the coverage areas. This may be related to the limited coverage due to bluetooth protocol, since codes would only work under identified areas. And such places had already printed codes of the several services. Queried about whether they would print a tag to carry with them, the majority said they wouldn't.

For the tags posted on walls, the answers regarding the comfort and ergonomics are divided between "at the eye level" and "at the arms level". Almost all interviewed people said feel no constraints using TRIPcodes in a public place.

4.3 Feedback perception

Regarding to the need of interaction confirmation, it appears that the majority (more than 71% in the surveys) prefer to see in the device a confirmation that the service has been successfully executed, except when the result of an interaction already includes a specific content as the reply to the stimulus.

A common observation was the desire to start using an application in a brief fraction of time after starting its execution on the device. As a rule, the users did not read the information on the display neither chose the “Help” option for getting further details. And since the start time (due to TripServer bluetooth discovery) could be long, they had tendency to select the "Search" option that should only be triggered if, after an automatic attempt, no TripServer was found.

Nevertheless, the majority of inquiries stated to understand, in advance, what would happen after a shoot over a tag and the several feedback possibilities.

4.4 Functional and technical constraints

The deployment of the system in a real-world setting has uncovered many functional and technical problems, many of which very relevant and complex to solve.

The installation of the TripReader on personal devices was full of problems ranging from completely different behaviours on different devices, even different models on the same brand, to freezing the device during the process. This situation would be much more difficult to detect in a laboratory experience.

The major functional dilemmas were the natural action of opening the regular camera application, instead of the TripReader, knowing that to interact they should shoot the tags. Besides that, not being prone to read displayed messages and/or wait for a ready state of the application, if it takes more than few seconds, were also big bottlenecks for wider acceptance.

Besides the cost, to accept installing an application the data security and functionalities provided were the most referred. After those ones, the confidence in who produced/distributed the application and simplicity of the interface are the most relevant factors.

Not knowing participation requisites, not receiving the application despite activating the bluetooth, the requirement to install a “strange” application or afraid of safety violations (a virus, or undesired access to personal data) were the main reasons for not to participate.

The reluctance of publically interact by this new approach did not came as a showstopper, though many times observed the participation by imitation. Also, reflected in the log analysis, when the evaluator was on the field providing support a greater number of interactions and site visitors were recorded by the application.

Interviews confirmed that the fact of the project being confined to a small area led individuals to consider less interesting those services targeted at group dynamics - Type II functionalities. A bigger coverage would dramatically increase the usefulness of services like “where is my Buddy”. On the other hand, public displays were a booster for easier adoption.

The lack of application security certificates causes the appearance of several confirmation messages. The mechanism implemented by mobile devices manufacturers in order to ensure some confidence and security from third-part applications, raises too many suspicions on potential users and brings down the purpose of this interaction model – “a functionality at a distance of a single click”, as confirmed by observation.

The difficulty in pushing the client installation file over bluetooth, the time spent on bluetooth discovery, the need for several attempts (sometimes more than 3) in order to successfully find and connect to a TripServer were obvious after analysing the application logs. At the same time, the process of spreading the client application (TripPusher) was considered excessive or even abusive, according to the interviewed participants.

After the evaluation period it was obvious the need of a mechanism that could alert users of the services unavailability and notify application administrator of such a state. If a particular service is announced but the system is in an unresponsiveness state, creates mistrust once the user can not determine the cause for not getting any response. From the system perspective, the failure might be caused by the user leaving the coverage area, services are not responding due to an unhandled exception, or simply slow response due to a stress peak. From the user’s perspective, the program has bugs, period.

Indeed, the decoding mechanism revealed some weak points, either by returning incorrect values, unable to decode the images, or just parsing errors were registered. These might have been caused by several reasons. Insufficient light, blurred shoot, too far away, too close, among others factors. These weighted 13% of all TripListener errors. The log analysis also showed too many faults in communications, both with TripPusher and TripListener. In this last case the direct consequence would obviously be a failure of, or non-response to, a user stimulus. This type of problems counted 68% of all errors.

The delay with the bluetooth discovery process induced users either to exit the application, to press a button to start search all over again, or even to think that the application was frozen. A strong difficulty verified, especially with the starters, resided in the perception of the need to wait for a connection with a TripServer. Thus, sometimes, when the safety mechanism asked whether they allow TripReader to access the device API, the users selected "No". Finally, as wireless protocol of limited coverage and very obstacle sensitive, user’s mobility is a factor of great importance. It was several times observed, users opened the application, moved up the place where they were, but could not connect or lost the session although they were able "to see the server" (suggesting that they were in a very close distance).

5. CONCLUSIONS

In conclusion on the overall goal of this study, the findings on factors that could potentiate the adoption of this technology are:

- Interface for "dummies": never assume an interface as simple and complete, it should be followed the approach of designing for users without any prior knowledge or experience on the subject.
- Inform without "manual": do not require extensive reading of information or a manual. Instead, provide clues on key points about what should/could be made in a given state.
- Interaction model is simple, but an initial introduction is required: a basic introduction of the concept – the client program, the connection and the *click* – should be provided.
- Images or appealing visual effects: advertising in public displays or posters with captivating images or visual effects do help. Possibly added of synthesized information instead of a simple raw text fashion.
- Applications tested in as many different devices as possible: when the goal is to go global, to be used by a broad range of people/entities, should be considered equally the possibility of several platforms, brands and models of devices trying to install and run the application. Without a standard truly implemented, it is the only way one will be sure that the program presents the data, or at least works, as expected.
- No more than 3 consecutives faults: always bear in mind that users will make its decision on the application/technology in the first two or three attempts. If they experience difficulties in these first attempts hardly will kept trying. In this particular case, the Bluetooth search has proved to be slow and, sometimes, requiring more than three consecutive searches to find a TripServer. It proved to be very harmful for the project.
- Power signal allegory: try to implement mechanisms which express to users an indication of whether they are within a coverage area, especially important if using short distance communication protocol.
- Deployment of truly desired services: to really promote greater usage, more than just suitable, it is necessary to deploy functionalities truly *desired* by the users.
- Inclusion of entertaining features: the idea that entertainment facilitates new technology acceptance was confirmed as well as the willing to participate/interact was increased. As a proof, the "Announcement" service was the most used and the one participants better remembered, by simply allowing to send messages to public displays.

Despite some limitations, it allowed to conclude visual codes provide good support as an interface between the user and the application, in some types of scenarios. Once the user gets introduced to the interaction model, and the initial installation issues are overcame, there will be no further difficulties in its use.

Although this was a study in a real environment, one can not omit some limitations. It should be emphasized that, for this study, were only considered students of a university course in the Information Technology area. These, in addition to not being in a representative number of the all population, are also holders of special skills such as leveraged knowledge on new technologies, which requires the utmost care in generalizing the results obtained here and in the inference of them for the all population. Despite all the efforts made, the adoption of the technology, in this particular case embodied in TRIP-codes, was well below the expected. There are two fundamental reasons for this: a lack of understanding of what services would be really interesting for the targeted users and the technical problems during the first weeks of the project evaluation phase. Therefore, there are strong believes that further studies, taking advantage of the findings of this work, could achieve greater knowledge and enhancements for this technology.

6. REFERENCES

[Ababsa04] Ababsa, Fakhr-eddine and Mallem, Malik. Robust Camera Pose Estimation Using 2D Fiducials Tracking for Real-Time Augmented Reality Systems, In Proc. 2004 ACM SIGGRAPH, (2004), pp.431-435.

[ActivePrint05] ActivePrint website, HP Labs, Bristol, visited in November 2005.
`http://activeprint.org/index.html`

[Ballagas06] Ballagas, Rafael, et al. The Smart Phone: A Ubiquitous Input Device, Pervasive Computing, IEEE, 5(1), (2006), pp.70-77.

[Colorcode05] Colorcode website, Colorzip Japan Inc., visited in November 2005.
`http://www.colorzip.co.jp/en/technology.html`

[Kindberg04] Kindberg, Tim, et al. How and Why People Use Camera Phones, Consumer Applications and Systems Laboratory, HP Laboratories, Bristol, November, 2004.

[Kindberg05] Kindberg, Tim, et al. I Saw This and Thought of You: Some Social Uses of Camera Phones, Consumer Applications and Systems Laboratory, HP Laboratories, Bristol, February, 2005.

[Mansley04] Mansley, Kieran, et al. The Carrot Approach: Encouraging use of location systems, Laboratory for Communication Engineering, Cambridge University, 2004.
`http://www.cl.cam.ac.uk/Research/DTG/publications/public/kjm25/mansley04carrot.pdf`

[Moravec02] Moravec, Kimberly. A grayscale reader for camera images of xerox dataglyphs, Xerox Research Centre, Meylan, France, 2002.

[Nuutinen05] Nuutinen, Mikko et al. PrintAccess – Final Report, TKK Media Technology, August, 2005.

[PaperClick05] PaperClick website, NeoMedia Technologies, visited in December 2005.
`http://www.paperclick.com/`

[PrintAccess05] PrintAccess website, Helsinki University of Technology, visited in December 2005.
`http://www.media.hut.fi/printaccess/research.html`

[Ravi06] Ravi, Nishkam, et al. Indoor Localization Using Camera Phones, Department of Computer Science, Rutgers University, Piscataway, USA, 2006.

[Rekimoto00] Rekimoto, Jun and Ayatsuka, Yuji. CyberCode: designing augmented reality environments with visual tags, In Proc. DARE 2000.
`http://www.csl.sony.co.jp/person/rekimoto.html`

[Rohs04a] Rohs, Michael. Real-World Interaction with Camera-Phones, Department of Computer Science, Swiss Federal Institute of Technology (ETH) Zurich, Switzerland, 2004.

[Rohs04b] Rohs, Michael and Gfeller, Beat. Using camera-equipped mobile phones for interacting with real-world objects, Department of Computer Science, ETH Zurich, 2004.

[Scott05] Scott, David, et al. Using visual tags to bypass bluetooth device discovery, SIGMOBILE, Mobile Computing and Communications Review 2(1), (2005), pp.41–53.

[Semacodes05] Semacodes website, Semacode Corporation, visited in October 2005.
`http://www.semacode.org/`

[Spotcodes05] Spotcodes website, Computer Laboratory, University of Cambridge, visited in October 2005.
`http://www.cl.cam.ac.uk/Research/SRG/netos/uid/spotcode.html`

[Toye07] Toye, Eleanor, et al. Interacting with mobile services: an evaluation of camera-phones and visual tags, Pers. Ubiquitous Computing, 11, (2007), pp.97–106.

[Tripcodes05] Tripcodes website, Laboratory for Communications Engineering, University of Cambridge, visited in December 2005.
`http://paginaspersonales.deusto.es/dipina/tripweb/trip.htm`

[VisualCodes05] VisualCodes website, Dept. of Computer Science, ETH Zurich, visited in October 2005.
`http://people.inf.ethz.ch/rohs/visualcodes`

[Wagner05] Wagner, Daniel, et al. Towards Massively Multi-User Augmented Reality on Handheld Devices, Third International Conference on Pervasive Computing (Pervasive 2005), Munich, Germany, May, 2005.